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## 10 JOULE HIGH VOLTAGE TRIGGER MICRO MARX\*

D. A. Platts  
Los Alamos National Laboratory  
Los Alamos, New Mexico 87544

Summary

A low energy Marx generator makes a convenient trigger for various spark gaps. With an output around 200 kV and a risetime less than 2 ns, the micro-Marx can multichannel field distortion gaps or fire a number of gaps without much gap-to-gap isolation. This design features small size, low cost, and good triggering characteristics. The complete unit is shown in Fig. 1.

Construction

The 8-stage Marx uses 2.7 nF 40-kV ceramic Murata capacitors. They are charged through 1.5-megohm, 2-watt carbon resistors (Fig. 2). The capacitors are held by 0.020-inch thick, 1/2-inch wide brass straps (Fig. 3) which are punched out in one operation by a special die. The charging resistors are soldered to the brass straps (Fig. 4). The capacitors and spark gaps are supported by a cast epoxy insulator shown in

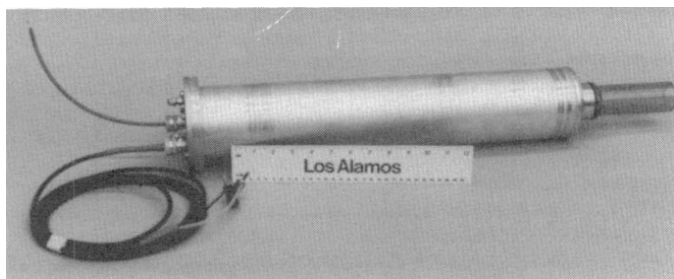


Fig. 1. Assembled micro-Marx shown with a 1-foot ruler.

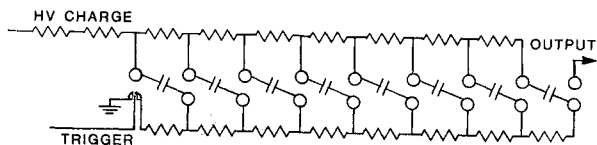


Fig. 2. Micro-Marx circuit diagram. All resistors are 1.5 M $\Omega$ , 2-W carbon. All capacitors are 2.7 nF, 40-kV ceramic.

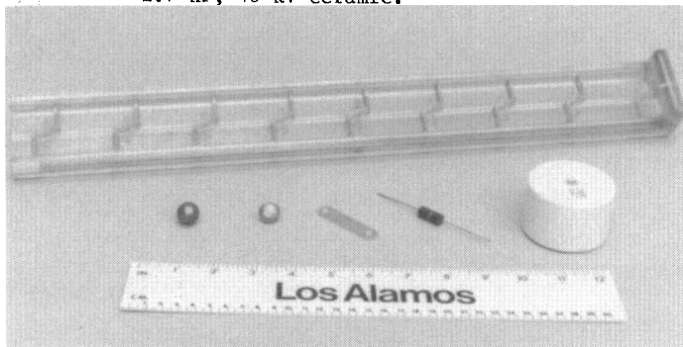


Fig. 3. Cast epoxy insulator with the components that mount on it.

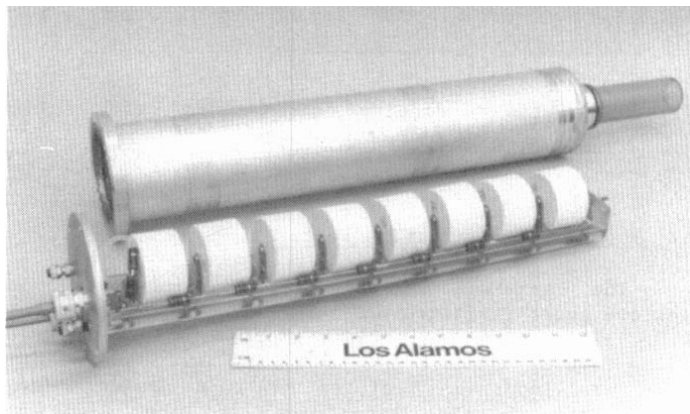


Fig. 4. Micro-Marx body and interior assembly.

Fig. 3. The spark gaps are 5/8-inch brass balls spaced 0.1 inch apart held to the epoxy insulator by 10-32 screws. Figure 5 shows the grooves which shadow the insulator and prevent surface flashover. The trigger ball is cut down and drilled to accept a cerama-seal feedthrough as seen in Figs. 3 and 5. The epoxy insulator is screwed to a 1/4-inch aluminum end plate. Electrical feedthroughs in the plate are commercial rubber compression fittings. (Fig. 4.) The housing is a 4-inch diameter, 1/16-inch wall aluminum tube 20 inches long. A bolt flange with an O-ring seal is welded to one end and mates to the 1/4-inch end plate. A one-piece epoxy insulator and air pressure seal is cast into the tube with a high-voltage feedthrough and output insulator at the opposite end (Fig. 6). The ground connection ring on the output end of the tube is sized to fit standard 2-inch copper pipe couplings and has an O-ring seal for use with insulating oil if desired. The Marx can be mounted by slotting part of a pipe connector and clamping it down on the ground ring with a hose clamp. The design of the output end of the Marx could be altered to incorporate any connector design.

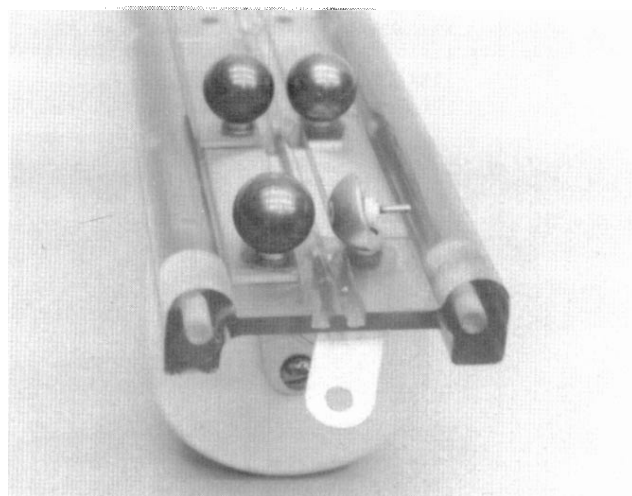


Fig. 5. End view of insulator with trigger ball and first two stages mounted.

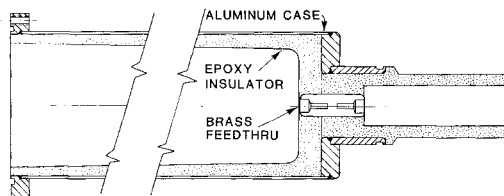


Fig. 6. Cutaway drawing of housing with cast insulator and feedthrough.

#### Design Features

The Marx was designed for low inductance to achieve short risetimes and low source impedance. The wide brass connecting straps, short path lengths, and close-fitting coaxial ground return provided by the case are important features of this design. The inductance of the capacitors is the limiting inductance. The close-fitting case provides a high stage-to-ground capacitance. This prevents the inter-stage stray capacitance from causing following stages to rise in voltage during erection of the Marx, which would cause long erection times and unreliable triggering.

The reliable triggering of the micro-Marx is also aided by the air pressure which insulates and suppresses corona as well as pressurizing the spark gaps. Corona in any spark gap system causes ionization and electrical noise, thus higher pressure is required to hold off the charge voltage which makes triggering difficult or impossible. Pressurizing the entire micro-Marx suppresses corona and avoids messy and complex insulation systems.

The cost has been minimized by reducing the number of parts and machining operations, using standard parts, eliminating critical tolerances, and making assembly simple.

#### Electrical Characteristics

The micro-Marx was connected to a high-voltage probe in parallel with a length of  $23\ \Omega$  cable as a load. The output is shown in Fig. 7 for a 20-kV charge voltage, instead of the normal 30 kV, to avoid probe damage. The observed 2-ns risetime in Fig. 8 equals the intrinsic probe response indicating that the micro-Marx risetime could be shorter.

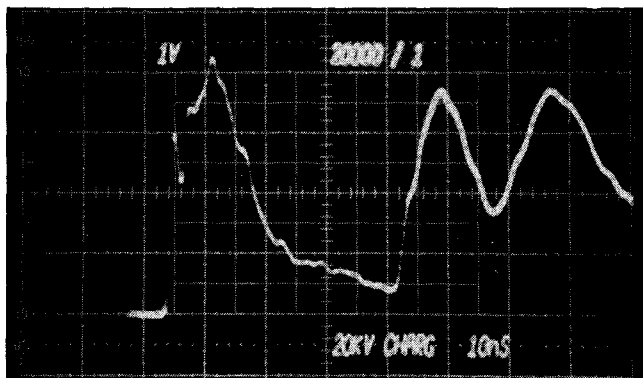


Fig. 7. Micro-Marx output into  $23\ \Omega$  load with 20 kV charge.  
10 ns/small division on the abscissa  
20-kV/small division on the ordinate.

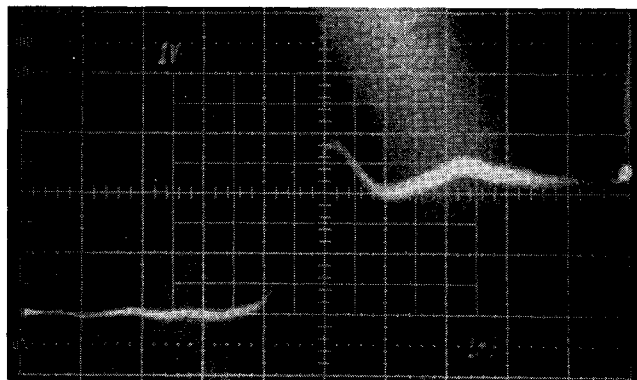


Fig. 8. Expanded version of Fig. 7 with 1 ns/small division on the abscissa.

One system triggered by the micro-Marx shows a total jitter of less than 5 ns. A 10-kV Krytron pulser feeds a 4:1 ferrite transformer to produce a 40-ns risetime trigger pulse for the Marx. Measurements will be made of the Marx risetime and erection time using a faster transmission line transformer.

A simple and entertaining test of micro-Marx risetime and voltage is provided by suspending a 1/16-inch wire about 3 inches above a ground plane. Figure 9 shows the result of firing one shot at atmospheric pressure.

An early micro-Marx prototype has been in service for several years firing two Scyllac gaps for over 10,000 shots. The new design is performing well on the High Density Z-pinch. The micro-Marx should become a useful pulsed power component at Los Alamos.

Thanks are due to: Gary Stelzer for his machine and assembly work, Pat Campbell for the epoxy casting, and John Power and Bill Nunally for the measurements of the output.

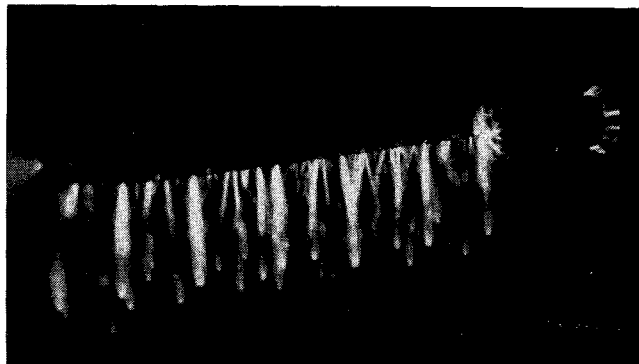


Fig. 9. One micro-Marx shot in air with 1/16-inch wire 18 inches long 3 inches above a ground plane.

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